

Development of a virtual supermarket shopping task for cognitive remediation of memory and executive functions in schizophrenia

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Abstract— Impairment of executive and memory functions was repeatedly observed in various neuropsychiatric disorders, such as schizophrenia. As the pharmacological treatment does not influence the deficit sufficiently, the significance of cognitive remediation increases in importance. The presented study introduces the virtual Supermarket Shopping Task (vSST), a novel method aimed at memory and executive functions, designed in ecologically valid environment. The results of the first pilot study showed significant difference in the performance between the males and females. In the second pilot, the difference between males and females was eliminated subsequently to adding other items besides groceries to the shopping list. The debriefing of participants pointed out the importance of elected encoding strategy. Considering adjustable parameters that allow us to increase the task difficulty and complexity, vSST represents potentially well-adjustable remediation method.

Keywords— virtual reality, remediation, cognitive deficit, memory, strategies

I. INTRODUCTION

Cognitive impairment is associated with various neuropsychiatric disorder, such as depression, obsessive-compulsive disorder or Alzheimer disease. Especially well-documented is the deficit of memory functions in schizophrenia (SZ) patients. The impairment of declarative memory in SZ is associated with well-defined deficit in semantic and episodic memory, typically assessed with recall and recognition of list of words [1]. Memory impairment seems to be concentrated around the disruption of conscious recollection and it apparently results from the failure in strategic processes [2]. Thus, the deficit seems to be connected to disturbed executive functions (EFs) [3] requiring engagement of prefrontal cortex (PFC), an area showing differential activation and connectivity in SZ [4]. As deficits in memory and executive functioning impact directly patients daily functioning, it is important to focus on developing suitable remediation methods.

Virtual shopping tasks have been already presented [5] and tested as potentially effective remediation [6] and diagnostic methods focused on executive [8] and memory functions [8].

II. METHOD

A. Participants

Eleven subjects without any neurological or psychiatric diagnosis (5 males, 6 females) were recruited for the first pilot study. The average age in the group was 25.73 ranging from 23 to 31 years (male 27.4±3.2, female 24.3±1.5). Six of the participants had education level 4 (university) and five participants had education level 3 (high school). The sample for the second pilot was formed from fifteen subjects (7 males, 8 females) with the average age 24.93 ranging from 18 to 32 years.

B. Cognitive assessment

Prior to completing vSST the participants were evaluated with a short battery of standard cognitive tests (Rey Auditory Verbal Learning Task, Logical memory (WMS-III), PEBL Continuous performance test, Trail Making Test) in order to compare vSST with standard psychological measures.

C. The virtual Supermarket Shopping Task (vSST)

The virtual Supermarket Shopping Task was specifically designed for remediation of EFs and memory deficit in ecologically valid environment using Unity game engine software (<https://unity3d.com/>). Prior to the beginning of the task, short Exploration phase was presented when the subject had 2 (or 3 minutes in the Pilot 2) minutes to familiarize with the controlling system and to get used to the virtual environment (VE). Thereafter, the participant was instructed to read and remember the shopping list, wait for 3 minutes and then intent to pick up the objects from the list in the supermarket in random order. The task was conducted in five consecutive trials with increasing difficulty level (with 3, 5, 7, 9 and 11 items presented as encoding material). Two sets of lists were created to eliminate the effect of irregularities and the lists were pseudorandomly applied in the two pilot studies. Each of the trials was divided in two main phases: Acquisition phase and Recall phase (see Fig.1). During the Acquisition phase the encoding material (grocery or ordinary supermarket items) was presented to the subject for the certain amount of

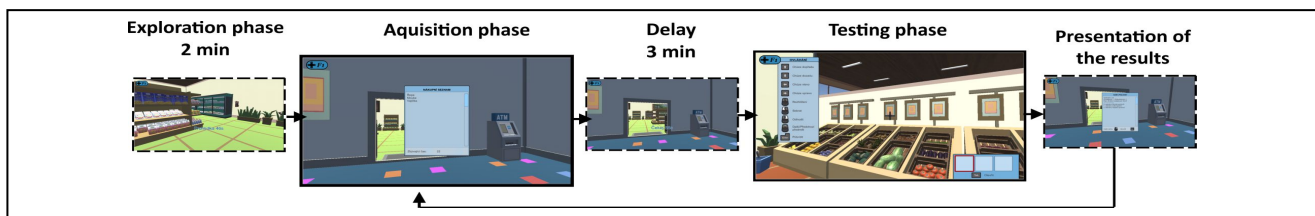


Fig. 1. Diagram capturing the sequence of individual phases of the vSST.

time in form of a shopping list. After specific delay interval (3 minutes), during which subject could not move in the VE and the list was not presented anymore, the Testing phase followed. Within the Testing phase the subject was supposed to find and pick up the learned objects from the list in the environment of virtual supermarket. The errors measured in individual trials could be composed from two types of mistakes – 1.) Intrusion error - picking up a wrong object and 2.) Omission error – missing some of the objects from the list.

D. Results

1) Cognitive assessment

No significant differences were found between males and females in performance measured using psychological tests ($p > 0.05$).

2) vSST

The analysis confirmed increasing number of errors, walked distance and trial time connected with increasing level difficulty (number of objects 3, 5, 7 and 11) ($p < 0.001$). The repeated measures ANOVA also revealed that the males performed significantly worse than females ($p < 0.05$) - see Fig.2.A. Additionally, an interaction effect 'trial*sex' was observed ($p < 0.05$), the Newman-Keuls post hoc test revealed that the sex specific differences are present only in higher difficulty levels (for 9 objects $p < 0.01$, nonsignificant trend for 11 objects $p = 0.052$). Importantly, the task performance did not differ between the two versions of the shopping lists. In the second pilot (when other items besides groceries were used), the difference between males and females was substantially weakened or fully eliminated – see Fig.2.B.

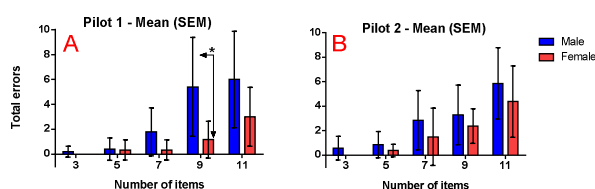


Fig. 2. Results of vSST for males and females in the Pilot 1 (A) and Pilot 2 (B).

3) Cognitive assessment and vSST

Significant ($p < 0.05$) negative correlation was found between number of errors in vSST with 11 objects and AVLT measures: AVLT total score trials I-V ($r = -0.82$), 30 min delayed performance ($r = -0.67$), and AVLT recognition ($r = -0.67$).

III. CONCLUSION

These findings support the idea of utilization vSST as remediation tool in patients with neuropsychiatric disorders, especially with SZ. It is in accordance with the previous studies using virtual shopping task [7]. A short debriefing with the

participants pointed out importance of encoding strategy as relevant predictor of their successful performance in the vSST. The observed effect of participants' sex seems to be influenced by the selection of strategy used to solve the task. While the females tended to cluster the list as a recipe or a menu of meal courses, males focused on spatial characteristics (e.g. location in the supermarket). Correspondingly, this was confirmed by the second pilot (where other items besides groceries were added to the list) where the performance between males and females was balanced. This might have practical impact for the remediation, as the disruption of self-initiation and execution of strategy apparently play important role in the cognitive deficits in SZ patients [4]. Additionally, besides adjustable difficulty level through increasing number of objects, the customizing of several parameters of the vSST (encoding material, length of encoding and delay period, etc.) enables to compile well-tailored remediation technique. Furthermore, combination of trajectory analysis and debriefing with participants permits to investigate planning, categorization, spatial abilities or encoding strategies. Currently, a study aimed at testing vSST on a group of patients with SZ and on a matched-sample comparison group of healthy volunteers is scheduled.

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REFERENCES

- [1] Aleman, A., Hijman, R., de Haan, E. H. F., & Kahn, R. S. (1999). Memory Impairment in Schizophrenia: A Meta-Analysis. *The American Journal Of Psychiatry*, 156(9), 1358-1366.
- [2] Danion, J. M., Huron, C., Vidailhet, P., & Berna, F. (2007). Functional Mechanisms of Episodic Memory Impairment in Schizophrenia [Online]. *The Canadian Journal Of Psychiatry*, 52(10), 693-701.
- [3] Orellana, G., & Slachevsky, A. (2013). Executive Functioning in Schizophrenia. *Frontiers In Psychiatry*, 4, 35.
- [4] Simons, J. S., & Spiers, H. J. (2003). Prefrontal and medial temporal lobe interactions in long-term memory. *Nature Reviews Neuroscience*, 4(8), 637-648.
- [5] Sangani, S., Weiss, P. L., Levin, M. F., & Fung, J. (2012). Development of a complex ecological virtual environment. In *Proc. 9th Intl Conf. Disability, Virtual Reality & Associated Technologies* (pp. 261-268). Laval, France: ICDVRAT.
- [6] Josman, N., Schenirderman, A. E., Klinger, E., & Shevil, E. (2009). Using virtual reality to evaluate executive functioning among persons with schizophrenia: A validity study. *Schizophrenia Research*, 115(2-3), 270-277.
- [7] Rand, D., Weiss, P. L., & Katz, N. (2009). Training Multitasking in a Virtual Supermarket: A Novel Intervention After Stroke. *American Journal Of Occupational Therapy*, 63, 535-542.
- [8] Kinsella, G. J., Ong, B., & Tucker, J. Traumatic Brain Injury and Prospective Memory in a Virtual Shopping Trip Task: Does It Matter Who Generates the Prospective Memory Target?.